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ABSTRACT

A pre-test is described that was developed to determine the deficiencies of students in a college-level life science course. Twenty-six competencies prerequisite to the understanding of the course were included in the test, which was administered to 69 students. No student posessed more than 20 competencies; a majority of the students could demonstrate no more than 8 competencies. These results are discussed with respect to programs that accept mainly transfer students who may exhibit a range of educational preparation. (MH)

in-ed

A monthly publication of The University of Texas of the Permian Basin devoted to innovative educational ideas, including self-paced instruction, in higher education.

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PURPOSE

IN-ED is a monthly publication of The University of Texas of the Permian Basin in Odessa, Texas. Its primary purpose is to describe procedures, problems and policies that may be involved in the operation of innovative programs in higher education.

Each month, IN-ED will describe some facet of the innovative programs of the university. It is hoped that these publications will be informative and helpful to other institutions considering the development of innovative programs.

Comments and suggestions about any facet of innovation in higher education will be welcomed.

Joel Greenspoon
Editor

INNOVATIVE TEACHING

Innovative teaching in higher education is the hottest topic in college and university circles. We were fortunate in being able, as a new university, to institute an across-the-board stress on self-paced instruction as well as other methods that give a fresh breath of life to teaching. We recruited top faculty from across the nation who not only were sympathetic to the new values and techniques but also were experienced in them or committed to employ them. One-fourth of our courses are taught in non-conventional ways, and our early experience proves to us we did not err.

There is, as a result, an improved learning efficiency and an ultimate cost-effectiveness that we expect to achieve—not to mention instilling in the student a lifetime learning capability.

For innovative and exciting new teaching challenges to be successful, the entire university community and particularly key administrators must be dedicated to the program. We at this university believe in it.

B. H. Amstead
President

COMPETENCIES IN THE PROCESSES OF SCIENCE OF TRANSFER STUDENTS AT THE UPPER LEVEL OF COLLEGE

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The article, "Competencies in the Processes of Science of Transfer Students at the Upper Level of College," is concerned with a most important issue in education, especially in self-paced instruction. This issue involves the differences in the preparation of students to acquire knowledge in a particular course. Professors Kurtz, McKinney and Wisdom have developed a pre-test that also functions as a part of the educational program of the student. The deficiencies of the students are determined and corrected before they begin the course itself.

This procedure ensures that each student has acquired the minimum entering behavior to make satisfactory and effective progress in the course.

The science program developed by the American Association for the Advancement of Science, *Science–A Process Approach*, describes several processes of science that are believed to be prerequisite to all scientific endeavors (1). The science processes were named observing, measuring, classifying, using space/time relationships, using numbers, communicating, predicting, inferring, defining operationally, controlling variables, constructing hypotheses, interpreting data and experimenting. Each of these processes was defined in terms of observable behaviors under a range of specified conditions. Here at UT Permian Basin we have combined, modified and extended to the college level some of the behaviors from the science processes in *Science–A Process Approach* to form a set of 26 competencies that we believe are prerequisite to the study of life science. That is, we hypothesize that a student who has acquired these 26 competencies will be more likely to succeed in a life science course or program than will a student who has not acquired them.

On the basis of this hypothesis, a diagnostic instrument was constructed for use in determining which of the science competencies each student already possesses prior to beginning the upper level life science program at UT Permian Basin. For most students, this is at the beginning of the junior year because the majority transfer to UT Permian Basin after earning 60 to 65 college credit hours at a junior college. The 26 prerequisite competencies probably should be part of the behavioral repertoire of a science student after completion of 60 credit hours, including 8 hours of general science, 6 to 12 hours of English and, in most cases, 3 hours of mathematics. We did not want to make such an assumption, however. Because of the opportunity to self-pace instruction at UT Permian Basin we desired to begin instruction for each student at his own unique level of competence. To do so was essential to diagnose the competence of each student without recourse to assumed competencies. It was also important for the instructors to be sure that each student does possess the 26 competencies so that the student can use the self-access laboratory safely and with confidence. To this end, a self-paced program of instruction was designed for helping students acquire the prerequisite science competencies they had not acquired prior to beginning the life science program.

This report is a summary of the results obtained with 69 students in life science courses who began their work in the Fall 1973 and were administered the diagnostic instrument for the 26 prerequisite science competencies.

Table 1 lists the 26 prerequisite science competencies (PSC) and the percentage of acceptable responses for each item on the diagnostic measure for the 69 students. Only the observable behaviors are stated in Table 1. A complete behavioral statement as defined by Walbesser *et al.* (2) was prepared for each PSC, including lists of materials provided to the student and criteria for judging acceptable responses. Figures 1a and 1b show the title page and first set of tasks from the diagnostic measure. In judging each student's response to an item in the diagnostic measure, the criteria for acceptability are applied to the response. If the response meets *all* it is acceptable; if the response meets only some or none of the criteria it is unacceptable. Thus each response is judged on a bipolar scale of acceptable or unacceptable. As an example of criteria for assessing each response, the criteria for 1PSC were:

> all three measurements of both objects must be in metric units;
>
> all measurements with an accuracy of 1 percent;
>
> all measurements expressed in significant figures.

Table 1. The 26 prerequisite science competencies and the percentage of students who could demonstrate each of them acceptably. There were 69 students in the study.

Acceptable Responses	Prerequisite Science Competency
49	1PSC. Demonstrate the measurement of length, mass and volume of a biological object in metric units.
9	2PSC. Demonstrate the linear measurement of a biological object or structure with a stereo and/or monocular microscope.

14 3PSC. Name the actual size of an organism or a part of it from an illustration and its magnification and name the magnification of an illustration given the object illustrated.

28 4PSC. Name the actual size of an organism or a part of it given an illustration and a scale for the illustration and construct a scale for an illustration when given the object and its illustration.

23 5PSC. Name the responding, manipulated, constant and uncontrolled variables given a description of an experiment or data from an experiment.

55 6PSC. Construct a coordinate graph from a table of data and a table of data from a graph.

9 7PSC. Apply rules for the use of logs to perform calculations.

6 8PSC. Demonstrate the preparation of specified volumes of solutions of specified molarity, normality, ppm and & (w/w, w/v, and v/v).

54 9PSC. Describe observable properties of organisms or their parts.

61 10PSC. Distinguish statements of observation from statements of inference.

57 11PSC. Name variables that may influence response of a process, organism, part of an organism, or a population, given a description of the situation.

14 12PSC. Construct a semi-log graph from data and construct a table of data from a semi-log graph.

10 13PSC. Apply a rule to calculate a specified value or quantity, given the rule and information or means to arrive at the values to be plugged into the rule.

30 14PSC. Identify an object (or structure, situation, relationship) by means of an operational definition.

48 15PSC. Construct a statement that describes in words the observations and pattern (if any) communicated in a graph or table.

16 16PSC. Construct predictions from a table or graph by interpolation and extrapolation, including a description of why you selected the predictions that you did.

57 17PSC. Construct alternative one-stage classifications of objects, observations or data.

16 18PSC. Construct a multistage classification of a set of objects, observations or data.

4 19PSC. Construct a word key from a multistage classification.

32 20PSC. Describe apparent likenesses and differences between sets of data.

57 21PSC. Name an object or property of an object based on a key which includes the object or property to be named.

7 22PSC. Distinguish statements of operational definitions from those that are not operational.

28 23PSC. Construct an operational definition of a term used in a scientific statement of key.

32 24PSC. Construct alternative inferences, explanations or questions to be answered about a set of data.

10 25PSC. Apply rules to calculate mean, mode, median, range and standard deviation, given data.

52 26PSC. Demonstrate how to find literature for a given topic in the UTPB library.

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30 Mean

DIAGNOSTIC MEASURE
FALL, 1973

Your name ______________________

Life Science Courses in which you are enrolled______________________

We regret the need to bomb you with such an extensive measure at this time. It's hardly the way to win friends! But as you know, we need to know your abilities so we can prescribe instruction for you at your level so that your and our time will be effectively used and you can proceed with confidence.

Please do the best you can on each problem but don't worry about any items you cannot do.

There is no grade on this measure.

You will be exempted from each module of instruction for which you already have the competence.

Skip a problem if you do not know how to answer it. But if you think you know how to answer it, give it a try.

Work at your own rate and by yourself.

The items do not have to be done in sequence. Just be sure to give them all your attention.

Don't spend more than 10 minutes on any one answer.

If you have to leave before you complete the diagnostic measure, place your response booklet in the box on one of the lab tables and retrieve it when you are ready to resume work another time.

Try to complete the measure during the week of September 10 to 14.

Materials for each problem should be at the station of nearby lab table. If you can't find what is needed, please ask the lab assistant who is on duty in the ERC.

Remember, your individualized instruction will be based on your responses. Be fair to yourself by trying as thoughtfully as you can.

WRITE ALL RESPONSES IN THIS BOOKLET.

Figure 1a. The title page of the diagnostic measure for the 26 prerequisite science competencies.

1PSC. There should be two biological objects in front of you. You are to measure the length, mass and volume of both objects. You may use any equipment necessary. Express all measurements in metric units and with significant figures only.

Common name of specimen:

Length: ______ ______

Mass: ______ ______

Volume: ______ ______

PLEASE CLEAN UP THE AREA WHEN YOU ARE THROUGH AND BEFORE YOU MOVE ON TO THE NEXT STATION.

2PSC. There should be two microscopes at this station: a monocular scope and a stereoscope. There are also slides, coverslips, metric rules, forceps, wipe tissues and two biological specimens. The two specimens are labeled "A" and "B".

Task 1. Prepare a wet mount of specimen "A". Using the monocular microscope and other materials available at this station, calibrate the field of vision under high dry objective and measure the length of three cells in the wet mount. Express the measurements in *microns*.

____

____

____

Briefly explain here how you made these measurements and show your calculations.

Task 2. Using the stereoscope and the rules, determine the dimensions in metric units of specimen "B"

Clean the slides and materials before going to the next station.

____

____

____

Figure 1b. The first two items on the diagnostic measure as administered to the students prior to any instruction in the fall 1973.

Standards of performance were set at levels estimated by prior teaching experience to be representative of science students with 60 credit hours of college work.

As shown in Table 1, none of the 26 competencies was possessed by less than 4 percent of the students but, as shown in Figure 2, no students possessed more than 20. A majority of the students could demonstrate no more than eight of the 26 competencies and two students could do none of them. The item with the highest percentage of acceptable responses was 10PSC, distinguishing statements of observation from statements of inference. The lowest performance levels were on "construct" and "demonstrate" behaviors (8 and 19 PSC), which require the multiple application of specific rules. In general, responses were unacceptable on tasks requiring the application of several rules.

The one task requiring the use of the library (26PSC) was acceptably demonstrated by approximately half of the students. However, the criteria established for an acceptable performance did not require use of abstract journals to obtain the necessary literature citations. Later questioning of students who performed acceptably on item 26PSC showed that few of them were even aware of the existence of *Chemical Abstracts, Biological Abstracts* and similar reference sources. Because of the importance of these journals to any literature search in science, in the future the criteria for acceptable performance of 26PSC will include citation of abstract journals.

The 69 students had no opportunity to review the competencies or study for the diagnostic measure prior to taking the measure. Therefore some unacceptable responses may be attributed to small errors which could be remedied by a short study period. The large majority of unacceptable responses may not be explained in this way, however. This became evident from working with the students during instruction *after* the diagnostic measure had been administered. For example, it was found that many students previously had not used a microscope, prepared their own solutions or

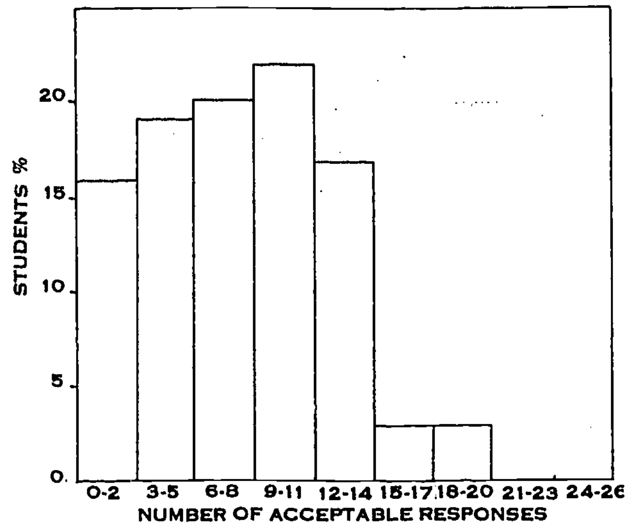

Figure 2. Frequency distribution of the total number of acceptable responses on the diagnostic measure.

learned how to use logarithms to make semi-log graphs, and few previously had heard about or used operational definitions. Many students knew how to use a classification key to name an organism (21PSC), but few could construct a key of their own design for a small set of organisms (18 and 19PSC). Learning how to make classification keys required time and effort on the students' part, so the unacceptable responses on the diagnostic measure to items 18 and 19PSC must not be attributable to small errors. Indeed, often students skipped items and made no attempt to respond. Many students were discouraged after taking the diagnostic measure, apparently because of their own feelings that they really should know how to do the tasks that were asked of them. Many words of encouragement from the instructors were needed to help some students complete the diagnostic measure as best they could and to remain in the program.

During the instruction that followed the diagnostic measure, the major block to a student's learning appeared to be his lack of confidence in his own decisions. That is, when students were doing the activities relating to learning how to construct an original classification of some biological objects, learning how to make operational definitions or learning how to make inferences from a set of data, they often were hesitant and appeared to lack confidence that their observations and ideas could actually be used and accepted. Because the emphasis in the science processes is in developing decision-making behaviors, this reluctance of students to believe in their own efforts probably is the major behavior that must be modified.

The diverse array of behavioral repertoires of the 69 students in the study make a very difficult task of the construction of a behavioral hierarchy of the 26 competencies which would be effective for instruction. It may be that three or more learning sequences are necessary to accommodate the variety of sets of competencies possessed by junior-level college students. It is clear from the data in this study that college transfers who have 60 or more credits earned have major individual differences. Instruction of these transfer students should be based on a diagnosis of these differences rather than on an assumed "common" set of competencies in the science processes.

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